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The Patent Office

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1. Your reference — CM00962S/DELLON/GBRI/MM/LCC

2. Patent application number *(The Patent Office will fill in this part)* — 07 JUN 2000 — 0013821.4

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

MOTOROLA ISRAEL LTD
16 Kremenetski Street
Tel Aviv 67899
Israel

07JUN00 E542917-1 D02319
F01/7700 0.00-0013821.4

Patents ADP number *(if you know it)* — 653440001

If the applicant is a corporate body, give the country/state of its incorporation — ISRAEL

4. Title of the invention — CIRCUIT AND METHOD FOR SIGNAL PHASE CONTROL IN A RADIO TRANSCEIVER

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

LAURA LITCHFIELD
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Patents ADP number *(if you know it)* — 7806318001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

☒ YES ☐ NO

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Continuation sheets of this form	
Description	7
Claim(s)	3
Abstract	1
Drawing(s)	2 4

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	4
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	1
Any other documents *(please specify)*	1 x FEE SHEET

11. I/We request the grant of a patent on the basis of this application.

Signature LLitchfield Date
LAURA LITCHFIELD 6/6/00

12. Name and daytime telephone number of person to contact in the United Kingdom MARC MORGAN 01256 790073

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Statement of inventorship and of right to grant of a patent

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference CM00962S/DELLON/GBRI/MM/LCC

2. Patent application number *(if you know it)* 07 JUN 2000 0013821.4

3. Full name of the or of each applicant ~~MOTOROLA ISRAEL LTD~~
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Israel

4. Title of the invention CIRCUIT AND METHOD FOR SIGNAL PHASE CONTROL IN A RADIO TRANSCEIVER

5. State how the applicant*(s)* derived the right from the inventor*(s)* to be granted a patent
THE INVENTORS ARE EMPLOYED BY THE APPLICANT.

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7. I/We believe that the person*(s)* named over the page *(and on any extra copies of this form)* is/are the inventor*(s)* of the invention which the above patent application relates to.

Signature LLitchfield
LAURA LITCHFIELD

Date
6/6/00

8. Name and daytime telephone number of person to contact in the United Kingdom MARC MORGAN 01256 790073

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Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

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6148720001

Patents ADP number *(if you know it)*:

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Patents ADP number *(if you know it)*:

Reminder

Have you signed the form?

CIRCUIT AND METHOD FOR SIGNAL PHASE CONTROL IN A RADIO TRANSCEIVER

Field of the Invention

This invention relates to phase control of signals. In communications systems such as, for example, radio communications systems, it may be necessary to control the phase of a received signal in order to facilitate subsequent processing of the signal.

Background of the Invention

In a particular type of homodyne or direct conversion transceiver, an I/Q (in-phase and quadrature-phase, respectively) modulator is used. A possible application for use of such a transceiver requires the transmission of two pulses of 1 µs duration of different phases 1 µs apart and then repeating after 100 µs. The pulses are transmitted onto material that responds with a signal (echo) 600 KHz less than the transmitted frequency. The echo is received 4 µs after the second pulse is transmitted. In practice, the echo may be almost completely covered by noise. By using a combination of different phases in the transmitted signal, this additive noise can be almost completely removed.

A received signal may arrive in an inconvenient phase or in a phase that cannot be used by the logic section to retrieve the information it contains. An algorithm in the

DSP (digital signal processor) section of the logic section sometimes can be used to control the phase of a received signal; however, the practicality of this is approach is dependent on the size of the memory available as well as on the power of the DSP used. In addition in many instances the logic section, with its DSP, cannot for one reason or another be modified. A solution that can be implemented simply in hardware is unavailable.

Heretofore, control of the phase of a received signal has been possible, using existing integrated circuits, only by using significant additional hardware such as additional synthesizers, I/Q modulators, or firmware implementations.

It is an object of the present invention to provide a circuit and method for phase control of a signal wherein the abovementioned disadvantage(s) may be alleviated.

Summary of the Invention

In accordance with a first aspect of the invention there is provided a circuit for controlling signal phase in a radio transceiver as claimed in claim 1.

The proposed solution to the controlling of the phase of a received signal problem raised above is to implement the controlling of the phase in the RF hardware section rather than in the logic/DSP section. This allows the use of inexpensive integrated circuits (IC's), which are currently widely available in the marketplace.

In accordance with a second aspect of the invention there is provided a method for controlling signal phase in a radio transceiver as claimed in claim 6.

Brief Description of the Drawings

Two radio transceivers incorporating the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 shows a block-schematic circuit diagram of a first, heterodyne radio transceiver; and

FIG. 2 shows a block-schematic circuit diagram of a second, homodyne radio transceiver.

Description of Preferred Embodiment(s)

Referring now to FIG. 1, a heterodyne radio transceiver 100 includes a synthesizer 102, in which a reference signal from a reference signal generator 104 is divided in a fractional-N divider 106 whose output signal is passed through a low pass filter 108 to control a voltage controlled oscillator (VCO) 110. The output of the VCO 110 is applied through a buffer 112 to produce the synthesizer output. The VCO output is also fed back to the fractional-N divider 106. The synthesizer output is applied to an I/Q modulator 114, which receives I and Q (i.e., in-phase and quadrature-phase respectively) signal

inputs (I_T and Q_T respectively). The output of the I/Q modulator 114 is applied to a power splitter 116, one of whose outputs is applied to an SPDT switch 118. The output from the switch 118 is applied to an RF power amplifier 120, whose output is applied (via a transmit/receive switch 122) to an antenna 124 for transmission.

Another output of the power splitter 116 is applied to an I/Q demodulator 126 and to a frequency divider 128.

For reception, the antenna 124 is connected (via the transmit/receive switch 122) through a band-pass filter 130, a low noise amplifier 132 and a band-pass filter 134 to one input of a mixer 136. Another input of the mixer 136 is connected to receive the output of the frequency divider 128. The output of the mixer 136 is applied through a low noise amplifier 138 and a band-pass filter 140 to an input of the I/Q demodulator 126. The demodulator 126 produces two outputs, which are applied through respective low-pass filters 142 and 144 to produce recovered I and Q received signals I_R and Q_R respectively.

In use of the transceiver 100, the I/Q modulator 114 receives a signal from the synthesizer 102. The I_T and Q_T input signals to the I/Q modulator 114 are provided by the logic section (not shown) of the transceiver. The I/Q modulated signal (having a carrier frequency f_0) from the modulator 114 enters the power splitter 116, where the signal is split into the signal that is passed on to the SPDT switch 118 which is used to create pulses for

transmission, and to provide a local oscillator signal for reception. The pulses from the SPDT switch 118 enter the RF power amplifier 120, from which they are transmitted out (through the transmit/receive switch 122) at the antenna 124.

The receiver signal split from the splitter 116 is further split to provide (via the frequency divider 128) a local oscillator signal, which has a frequency $f_0/2$ (i.e., half that of the signal from the splitter 116) for down-conversion of the RF signal in the receiver section.

A received signal enters the radio through the antenna 124 and is routed by way of the transmit/receive switch 122 to the receiver section of the transceiver. The received signal is band limited by the band-pass filter 130 and amplified by the low noise amplifier 132. The signal is then filtered again by the band-pass filter 134, and applied to the mixer 136, where it is down-converted to a frequency of $f_0/2$ (i.e., one half of the local oscillator frequency). From the mixer 136, the signal is then amplified further by the low noise amplifier 138 (in order to provide extra amplification to the signal level which may be extremely small), and filtered by the band-pass filter 140, before being applied to the I/Q demodulator 126. The local oscillator signal for the I/Q demodulator 126 is provided by the output of the I/Q modulator 114. Therefore any change to the phase in the I/Q modulator 114, by way of the original I and Q lines of the I/Q modulator, will appear in the local oscillator signal of the I/Q demodulator 126. The phase of the signal at the output of the I/Q

demodulator 126 will therefore be determined by that of the signals I_T and Q_T on the I and Q lines of the I/Q modulator 114.

The I and Q demodulated outputs of the I/Q demodulator 126 signal are then low-pass filtered by the respective low-pass filters 142 and 144 to produce recovered I and Q received signals I_R and Q_R, which are passed to logic circuitry (not shown) of the transceiver.

It will be understood that, if desired, the principle of the circuit and method for phase control of a signal described above in the heterodyne transceiver 100 can be implemented in a homodyne or direct conversion radio transceiver as shown in FIG. 2. The overall configuration of the homodyne transceiver 200 is very similar to that of the heterodyne transceiver 100, and like components are given the same reference numerals. However, it is to be noted that in the homodyne transceiver 200, the following components of FIG. 1 are absent: the frequency divider 128, the mixer 136, the low noise amplifier 140 and the band-pass filter 140. In the homodyne transceiver 200, the received signal is applied from the band-pass filter 134 directly to the I/Q demodulator 126, and the signal from the power splitter 116 is applied directly to I/Q demodulator 126.

It will be appreciated that in the homodyne transceiver 200, as in the heterodyne transceiver 100, any change to the phase in the I/Q modulator 114, by way of the original I and Q lines of the I/Q modulator, will appear in the local oscillator signal of the I/Q demodulator

126. The phase of the signal at the output of the I/Q demodulator 126 will therefore be determined by that of the signals I_T and Q_T on the I and Q lines of the I/Q modulator 114.

It will be understood that the circuits and methods for phase control of a signal described above, by taking the output of the I/Q modulator to the I/Q demodulator in this way, enable complete control of the phase of the demodulated signals by way of controlling during reception the inputs of the modulator. A radio transceiver utilizing this approach may use existing integrated circuits (for, for example, the synthesizer 102, the I/Q modulator 114 and the I/Q demodulator 126) without any additional synthesizers, firmware, or additional high-cost hardware.

Claims

1. A circuit for controlling signal phase in a radio transceiver, the circuit comprising:

   modulator means for receiving signals for modulation on a carrier to produce a modulated carrier transmission signal for transmission; and

   demodulator means for receiving a modulated carrier reception signal to recover therefrom signals modulated thereon,

   wherein the demodulator means is coupled to the modulator means to receive therefrom the modulated carrier transmission signal for use in demodulating the modulated carrier reception signal, whereby the phase of the signals recovered from the modulated carrier reception signal is controlled by the phase of the signals received by the modulator means for modulation.

2. The circuit according to claim 1, wherein the signals received by the modulator means for modulation, and the signals recovered by the demodulator means, are in-phase and quadrature-phase signals.

3. The circuit according to claim 1 or 2, further comprising mixer means coupled to receive a signal representative of the modulated carrier reception signal and coupled to receive a signal representative of the modulated carrier transmission signal.

4. The circuit according to claim 3, wherein the signal representative of the modulated carrier transmission signal is frequency divided therefrom.

5. The circuit according to claim 4, wherein the signal representative of the modulated carrier transmission signal has a frequency which is substantially half that of the modulated carrier transmission signal.

6. The circuit according to claim 1 or 2, wherein the radio transceiver is a homodyne transceiver.

7. A method for controlling signal phase in a radio transceiver, the method comprising:

providing modulator means receiving signals for modulation on a carrier and producing a modulated carrier transmission signal for transmission; and

providing demodulator means receiving a modulated carrier reception signal and recovering therefrom signals modulated thereon,

wherein the demodulator means is coupled to the modulator means and receives therefrom the modulated carrier transmission signal for use in demodulating the modulated carrier reception signal, whereby the phase of the signals recovered from the modulated carrier reception signal is controlled by the phase of the signals received by the modulator means for modulation.

8. The method according to claim 7, wherein the signals received by the modulator means for modulation, and the signals recovered by the demodulator means, are in-phase and quadrature-phase signals.

9. The method according to claim 7 or 8, further comprising providing mixer means receiving a signal representative of the modulated carrier reception signal and receiving a signal representative of the modulated carrier transmission signal.

10. The method according to claim 9, wherein the signal representative of the modulated carrier transmission signal is frequency divided therefrom.

11. The method according to claim 10, wherein the signal representative of the modulated carrier transmission signal has a frequency which is substantially half that of the modulated carrier transmission signal.

12. The method according to claim 7 or 8, wherein the radio transceiver is a homodyne transceiver.

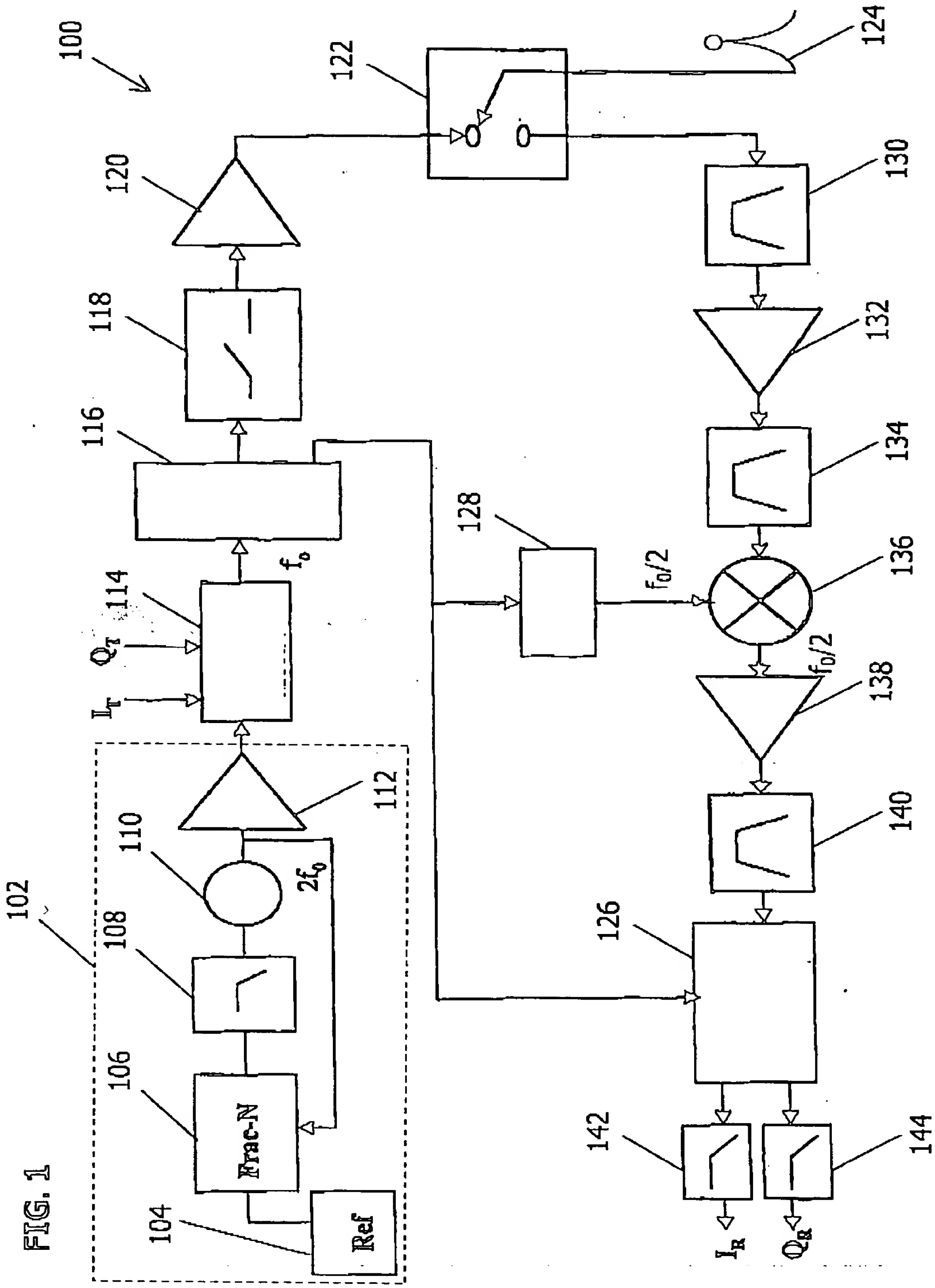
13. A circuit for controlling signal phase in a radio transceiver substantially as hereinbefore described with reference to FIG. 1 or FIG. 2 of the accompanying drawings.

14. A method for controlling signal phase in a radio transceiver substantially as hereinbefore described with reference to FIG. 1 or FIG. 2 of the accompanying drawings.

Abstract

CIRCUIT AND METHOD FOR SIGNAL PHASE CONTROL IN A RADIO TRANSCEIVER

A circuit and method for controlling signal phase in a radio transceiver (100) by: providing a modulator (114) receiving signals (I_T, Q_T) for modulation on a carrier and producing a modulated carrier transmission signal for transmission; providing a demodulator (126) receiving and demodulating a modulated carrier reception signal to recovering the modulated signals (I_R, Q_R), wherein the demodulator receives the modulated carrier transmission signal and uses it in demodulating the modulated carrier reception signal, whereby the phase of the recovered signals is controlled by the phase of the signals received for modulation. Taking the output of the modulator to the demodulator in this way enables complete control of the phase of the demodulated signals by way of controlling during reception the inputs of the modulator. Such a transceiver may use existing integrated circuits without any additional synthesizers, firmware, or additional high-cost hardware. The same principle can also be applied in a homodyne transceiver 200.


100
102
104
Ref
106
Frac-N
108
110
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112
I_T
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118
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144
I_R
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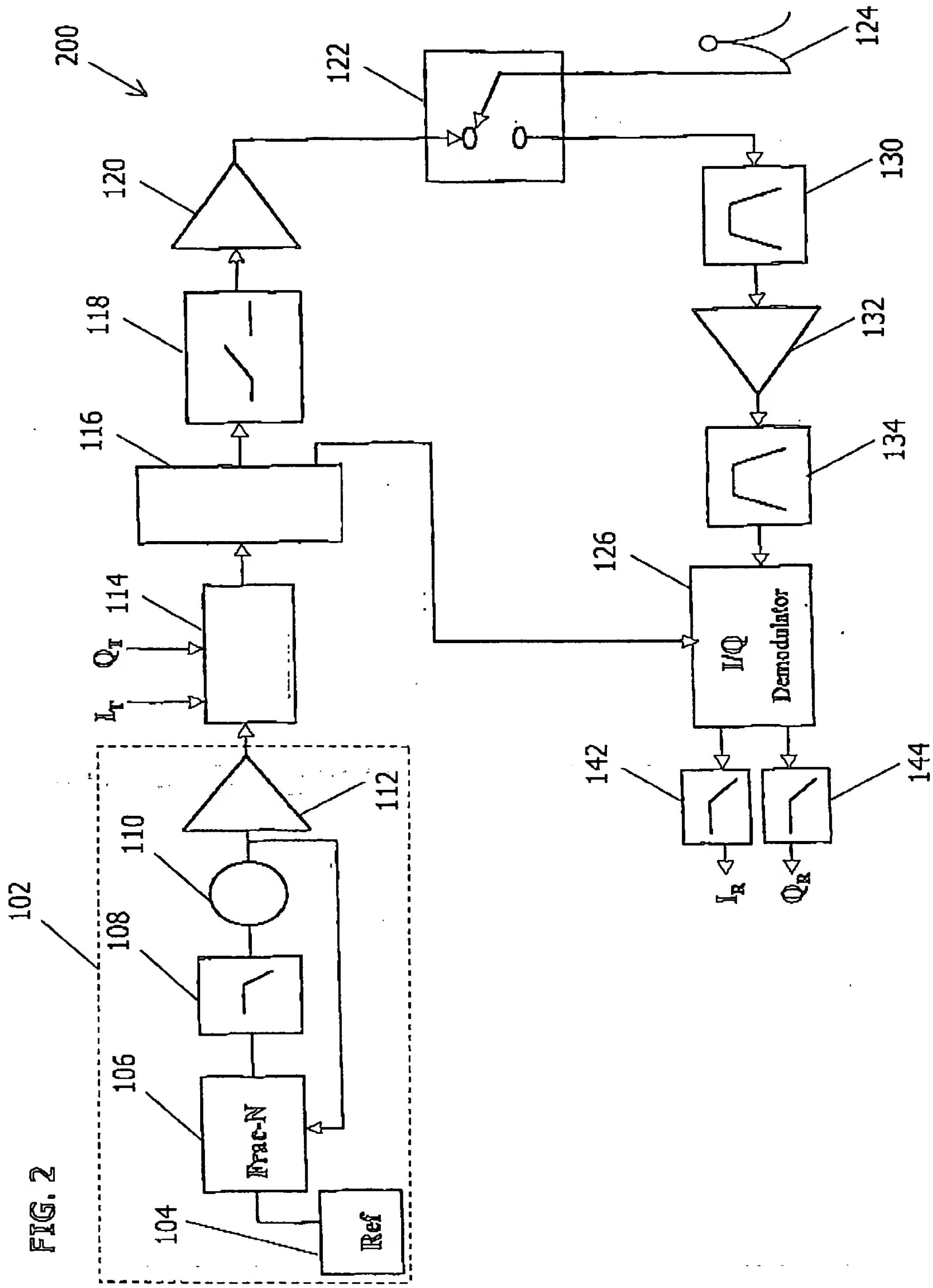
FIG. 1


200
122
124
120
130
118
132
116
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126
114
Q_T
I_T
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Demodulator
142
144
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110
102
108
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Frac-N
104
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FIG. 2